US006328482B1

(12) **United States Patent**
Jian

(10) **Patent No.: US 6,328,482 B1**
(45) **Date of Patent: Dec. 11, 2001**

(54) **MULTILAYER OPTICAL FIBER COUPLER**

(76) Inventor: **Benjamin Bin Jian**, 233 N. Mollison Ave. #51, El Cajon, CA (US) 92021

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/327,826**

(22) Filed: **Jun. 8, 1999**

Related U.S. Application Data

(60) Provisional application No. 60/088,374, filed on Jun. 8, 1998, and provisional application No. 60/098,932, filed on Sep. 3, 1998.

(51) **Int. Cl.**[7] **G02B 6/36**

(52) **U.S. Cl.** **385/88**; 385/93; 385/33; 385/34; 385/89

(58) **Field of Search** 385/33, 88–94

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,968,564		7/1976	Springthorpe .
4,292,512	*	9/1981	Miller et al. .
4,466,696		8/1984	Carney .
4,897,711		1/1990	Blonder et al. .
4,934,784	*	6/1990	Kapany et al. .
4,945,400		7/1990	Blonder et al. .
5,181,224		1/1993	Snyder .
5,195,150		3/1993	Stegmueller et al. .
5,247,597		9/1993	Blacha et al. .
5,259,054		11/1993	Benzoni et al. .
5,337,398		8/1994	Benzoni et al. .
5,345,529		9/1994	Sizer, II et al. .
5,346,583		9/1994	Basavanhally .
5,434,939		7/1995	Matsuda .
5,471,552		11/1995	Wuu et al. .
5,501,893		3/1996	Laermer et al. .
5,742,720		4/1998	Kobayashi et al. .
6,023,546	*	2/2000	Tachigori .

FOREIGN PATENT DOCUMENTS

6-138341 5/1994 (JP) .

OTHER PUBLICATIONS

Carson et al., "Future Manufacturing Techniques for Stacked MCM Interconnections", Journal of Metal, Jun. 1994, pp. 51–55.

Ko et al., "Bonding Techniques for Microsensors", Micromachining and Micropackaging of Transducers, Elsevier Science Publisher, Amsterdam, 1996, pp. 41–61.

Lee et al., "Low Cost High Quality Fabrication Methods and CAD for Diffractive Optics and Computer Holograms Compatible with Micro–Electronics and Micro–Mechanics Fabrication", Diffractive Optics and Optical Microsystems, Plenum Press, New York, 1997, pp. 133–138.

(List continued on next page.)

Primary Examiner—Hung N. Ngo
(74) *Attorney, Agent, or Firm*—Law Offices of James P. McFarland

(57) **ABSTRACT**

A multilayer optical fiber coupler for coupling optical radiation between an optical device and an optical fiber, including a first layer that has a fiber socket formed by photolithographic masking and etching to extend through said first layer, and a second layer bonded to the first layer. The first layer may comprise substantially single-crystal silicon. An optical fiber is inserted into the fiber socket to align the optical fiber precisely within the fiber socket. In one embodiment the optical fiber is a single mode fiber, and an optical focusing element formed on the second layer is aligned with the core of the single mode fiber. The second layer may comprise glass having an index of refraction that approximately matches the index of the optical fiber, and an optical epoxy is used to affix the optical fiber into the fiber socket and fill the gaps between the end face of the fiber and the second layer. Embodiments are disclosed in which an optical device such as a VCSEL or photodetector is bonded to the second layer. Alternative embodiments are disclosed in which the optical device is incorporated into the second layer. Advantages include reduced cost due to batch fabrication techniques, and passive alignment of the optical fiber.

29 Claims, 8 Drawing Sheets